Proposed Use of the NASA Ames Nebula Cloud Computing Platform for Numerical Weather Prediction and the Distribution of High Resolution Satellite Imagery

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The development of the Nebula Cloud Computing Platform at NASA Ames Research Center provides an open-source solution for the deployment of scalable computing and storage capabilities relevant to the execution of real-time weather forecasts and the distribution of high resolution satellite data to the operational weather community. Two projects at Marshall Space Flight Center may benefit from use of the Nebula system. The NASA Short-term Prediction Research and Transition (SPoRT) Center facilitates the use of unique NASA satellite data and research capabilities in the operational weather community by providing datasets relevant to numerical weather prediction, and satellite data sets useful in weather analysis. SERVIR provides satellite data products for decision support, emphasizing environmental threats such as wildfires, floods, landslides, and other hazards, with interests in numerical weather prediction in support of disaster response.

The Weather Research and Forecast (WRF) model Environmental Modeling System (WRF-EMS) has been configured for Nebula cloud computing use via the creation of a disk image and deployment of repeated instances. Given the available infrastructure within Nebula and the "infrastructure as a service" concept, the system appears well-suited for the rapid deployment of additional forecast models over different domains, in response to real-time research applications or disaster response. Future investigations into Nebula capabilities will focus on the development of a web mapping server and load balancing configuration to support the distribution of high resolution satellite data sets to users within the National Weather Service and international partners of SERVIR.

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SERVIR.NET
Earth Observation Science for Development

NASA

SPoRT

Background



- SERVIR – the Regional Visualization and Monitoring System
- Applies Earth observations and predictive models to support decision-making by government officials, managers, scientists, researchers, students, and the public.
- Improved monitoring of environmental threats, air quality, extreme weather, biodiversity, and changes in land cover.



- Transitions NASA satellite data and research capabilities to the weather forecasting community.
- Demonstrate societal benefit of NASA resources by improving short-term weather analysis and forecasting capabilities.

Modeling Capabilities with Nebula

- Application Concept:
 - Create Nebula images that are capable of supporting the research and operational goals of both SERVIR and SPoRT.
 - Potential benefits:
 - Rapid deployment of standard models to respond to natural disasters, without disrupting other activities.
 - Reduces the installation and maintenance of IT resources at remote or offsite locations.

Weather Forecasting

- Severe weather is a natural hazard of interest to both SERVIR and SPoRT.
- Use the Weather Research and Forecasting (WRF) Model to produce high-resolution, short-term forecasts.
- Instances can be used to:
 - Use one instance for a single region.
 - Share resources for a high resolution run or a larger forecast domain.
 - Provide rapid response to new events or research opportunities without impacting other resources.
- Other potential applications:
 - Air quality (GOCART)
 - Soil moisture (NASA LIS)
 - Hydrologic modeling



WRF Image

Instance #1

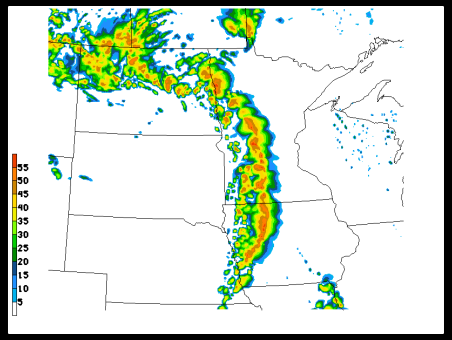


Image: SPoRT

Instance #2

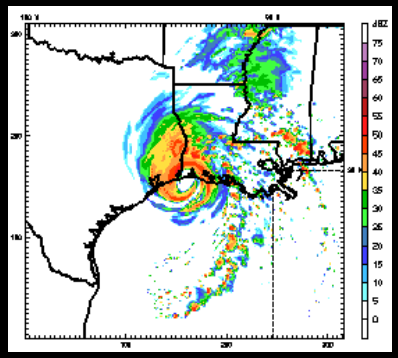
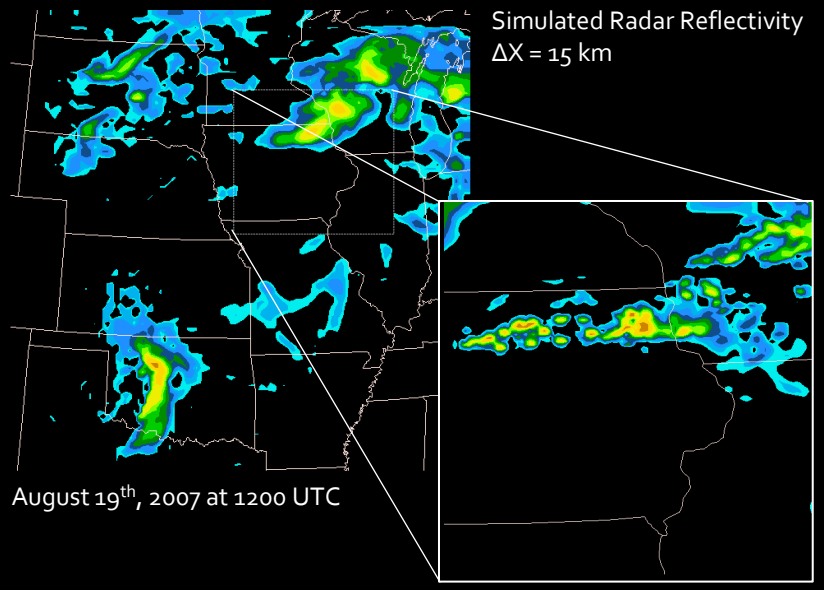


Image: UCAR

Early Achievements

- SPoRT and SERVIR are climbing the learning curve on Nebula, but have produced the following:
 - Benchmarking cases of the WRF model for a nested-grid, severe storm forecast.
 - Single image containing WRF V3.1.1 and companion codes for potential real-time application.



Benchmark Specifics:

Model Dynamics Core: ARW
CPU Speed: 2266.7 MHz
CPUs: 1
Cores: 4
Memory: 8 GB
Version: 3.1.1.5.1
Simulation time: 00:58:47
18-hour forecast cycle.

$$\frac{\text{1 real time hour}}{\text{18 forecast hours}}$$

"0.05 of real-time"

Current Limitations

- In order to provide value, forecasts must provide an appropriate amount of lead time.
- Depending upon the model type, domain characteristics, and physics, may require:
 - Large CPU and memory requirements
 - Instances with more horsepower, or parallel computing.
 - Post-processing and distribution
 - Requires a means of producing output for distribution off of Nebula and outside of the VPN for end users.

Data Distribution

- SERVIR and SPoRT require a means of distributing products to end users.
- Current models, satellites, and future capabilities require a system to handle large data volumes.
- Instances, web-driven applications and idealized scaling of resources can assist with query-based systems.
- By requesting data as needed, this offers a paradigm shift from providing all data, all the time.

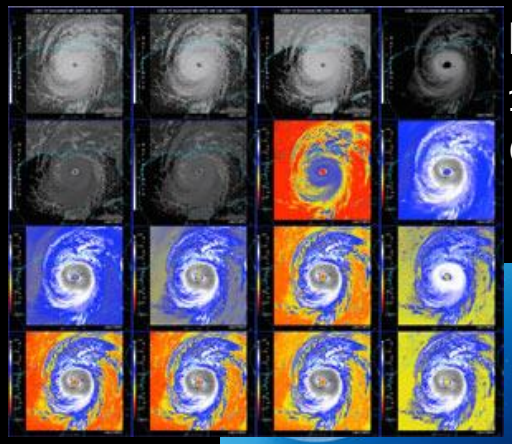
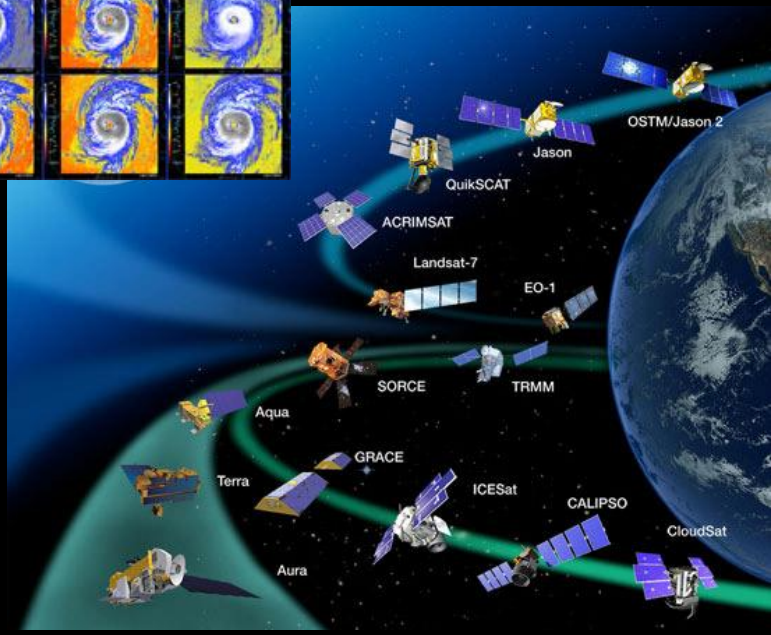


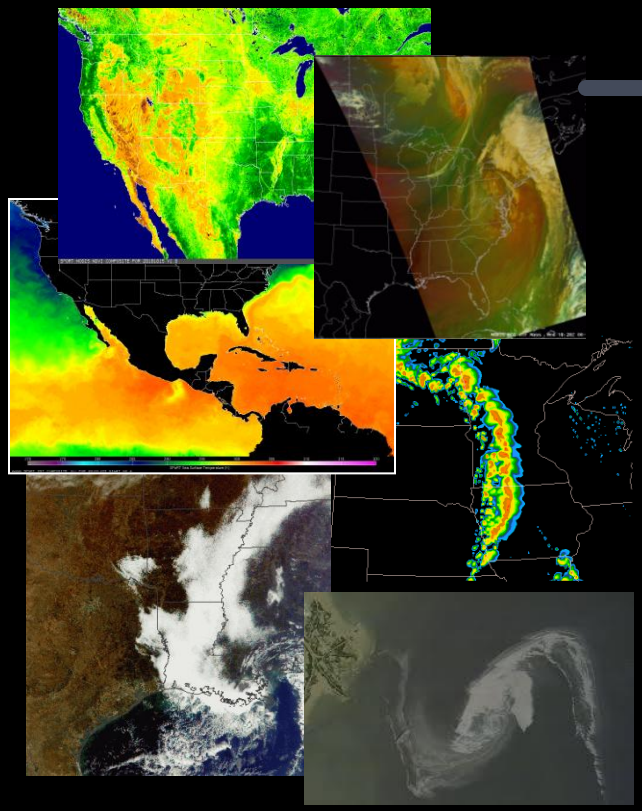
Image: UW/CIMSS

Future GOES-R
16 bands + lightning
(geostationary)



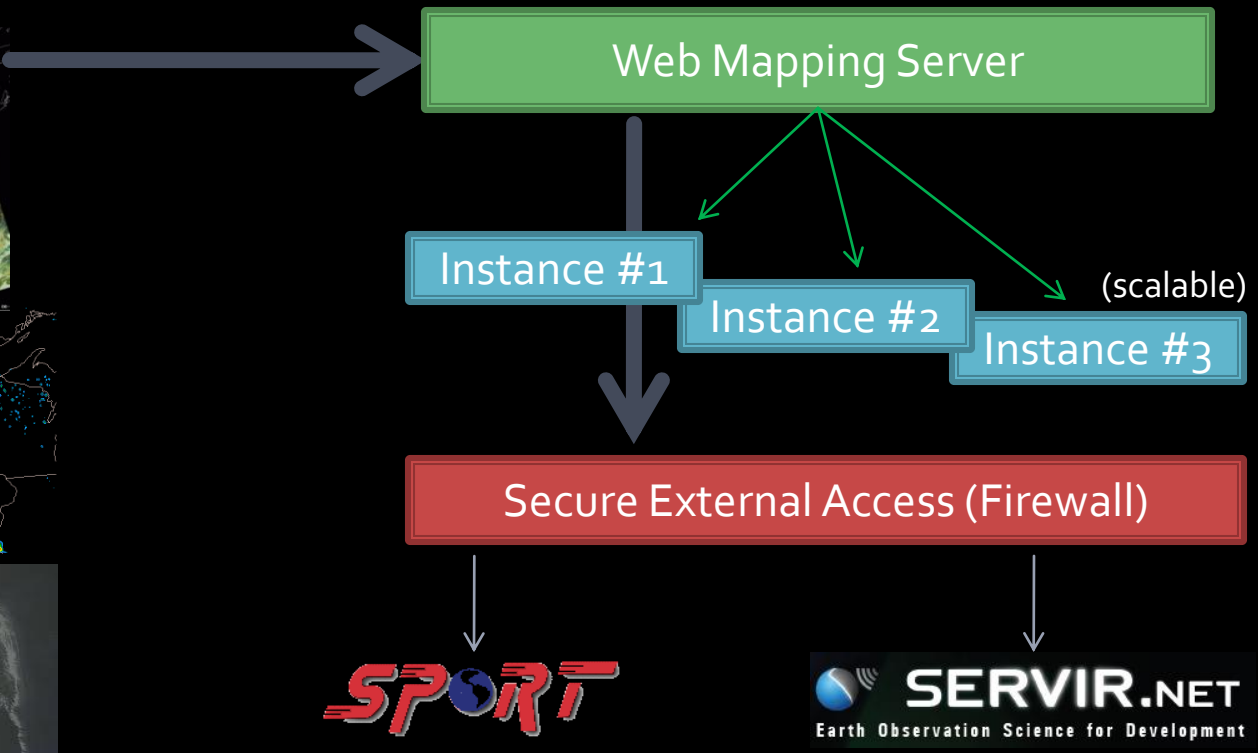
NASA Polar Orbiters

Potential Applications



GOAL

SERVIR/SPoRT Products
Produced or Hosted on Nebula



- NOAA National Weather Service
- "AWIPS II" Data Integration
- High resolution data on demand

- International Partner Nodes
- Himalaya, Africa, Mesoamerica
- Google Earth/GIS Applications

Our "Learning Curve" on Nebula



June 2010
Briefed on Nebula

August 2010
Created first WRF Image
Performed benchmarks

October 2010
Running instance with real-time model on crontab.

November 2010
Participating in online training for Nebula

Challenges:

- Scientists by training with limited IT administration skill sets, particularly with "clouds"
 - "I know where I would like to go, but I'm not quite sure how to get there…"
- Limited resources to allocate in competition with other project assignments
- Firewall, VPN, and other technical challenges to working with an off-site system

Noted Improvements:

- Conference calls and online resources **have dramatically improved** since launch!

Wish List

- Additional Training and Collaboration
 - Online, bi-weekly conference calls are a great way to facilitate training.
 - Could these be transitioned to online, formal training modules?
 - Future workshops or conferences highlighting projects on Nebula to encourage collaborative discussions or proposal opportunities.
 - We would benefit greatly by combining our science and modeling backgrounds with IT professionals that can demonstrate methods of leveraging cloud resources.

Future Work

- 2011 Goals
 - Create an instance featuring SPoRT and SERVIR modeling needs:
 - NASA "Unified WRF" (NU-WRF) Model
 - Includes land surface modeling, air quality, and weather forecasts
 - Scripts to facilitate real-time or archival runs
 - Improve connectivity between our Center and Nebula resources:
 - Determine feasibility of transitioning data from Nebula to end partners without web mapping capabilities
 - Use Nebula resources to fully support a SERVIR or SPoRT research and development activity.
 - Investigate methods for web mapping server distribution of real-time model output and satellite data.

Questions?

- Contact information:
 - Andrew Molthan
 - MSFC Earth Science Office (VP61)
 - andrew.molthan@nasa.gov
- Project websites:
 - http://www.servir.net
 - http://weather.msfc.nasa.gov/sport





- Please let me know if we can collaborate in our use of Nebula resources!